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October 25, 2011

<u>VIA ELECTRONIC FILING</u>

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Room TW-B204
Washington, DC 20554

Re: ET Docket No. 11-90; RM-11555; ET Docket No. 10-28; ***EX PARTE***

Dear Ms. Dortch:

On behalf of Toyota Motor North America, Inc. and Toyota Motor Corporation (collectively, "Toyota"), please find attached two additional items of analysis for consideration by the Commission in the above-referenced proceedings.

The first item, appended as Exhibit 1, elaborates on technical differences between vehicle-mounted and fixed radar devices and installations. Toyota has conducted a comparison between these various types of fixed radar installations and vehicle-mounted radars based on hypothetical scenarios. The analysis indicates potential adverse effects of electromagnetic interference to vehicle-mounted radar devices by a specific type of fixed radar installation. As previously expressed on the record in this proceeding, Toyota remains very concerned that if the use of fixed radars is allowed on an unlicensed basis, radars with various systems may appear in many locations, resulting in an increased risk of interference to vehicle mounted radars that may affect their performance and potentially pose a safety risk to consumers. Toyota respectfully asks the Commission to initiate a further inquiry to explore this issue more fully.

Second, Toyota wishes to address further the concerns raised by the National Radio Astronomy Observatory ("NRAO"). As Toyota has already observed, there is no evidence that vehicular radar operations would cause harmful interference to radio astronomy installations, and NRAO's interference allegations are contrary to approximately ten years of real-world experience with automotive radar systems in the United States and Europe. In the slides appended at Exhibit 2, Toyota addresses certain claims in NRAO's comments and submits analysis to show that the claims are not realistic. Toyota is convinced, and the record in this proceeding demonstrates, that vehicular radars at 76-77 GHz will be compatible with radio astronomy operations if the Commission adopts Toyota's proposed revisions to the rules on vehicular radar emissions limits.

Please contact the undersigned should you have any questions.

Very truly yours,

- /s/ -

James H. Barker

Counsel for Toyota Motor North America, Inc., and
Toyota Motor Corporation

EXHIBIT 1

A Comparison of Vehicle-Mounted and Fixed Radar Systems

Submitted to the Federal Communications Commission

by the Toyota Motor Corporation

October 2011

Summary

In response to questions about the technical differences between vehicle-mounted and fixed radar devices and installations, the Toyota Motor Corporation would like to provide an analysis and further information on this topic to the Federal Communications Commission.

The discussion that follows assumes that there are at least four types of fixed radars that would be expected to be used if the rules for fixed radars in the 76-77 GHz band are adopted by the Commission as proposed (see References 1-4). Toyota has conducted a comparison between these various types of fixed radar installations and vehicle-mounted radars based on hypothetical scenarios. The analysis indicates potential adverse effects of electromagnetic interference to vehicle-mounted radar devices by a specific type of fixed radar installation. Toyota is deeply concerned that if the use of fixed radars is allowed on an unlicensed basis, radars with various systems may appear in many locations, resulting in an increased risk of interference to vehicle mounted radars that may affect their performance and potentially pose a safety risk to consumers. At a minimum, these issues appear to warrant further study and consideration.

(1) Fixed Radar for Monitoring Vehicle Speed

One of the characteristics of this type of radar is that it assumes vehicles as targets, and it is supposed to detect the speed of a targeted vehicle. Radar waves are emitted in the area covering the lanes of traffic. Directional detection is not required for cases where the radar is not intended to monitor multiple lanes at the same time. Since the target of detection is only vehicle speed, continuous wave (CW) radar is more likely to be used, and the use of more expensive modulated radar is not necessary.

These types of radar devices are likely to be installed over the road for the radar beams to propagate. For accurate speed detection, fixed speed-monitoring radar beams are aimed at the front of a vehicle, and the beam should cover a certain distance. Since detecting direction is not required for these fixed radar systems, it is necessary to narrow the coverage area within the traffic lane to prevent potential interference.

Fixed radar, installed over the road, may be uncovered, not requiring a secondary surface. It is unlikely that the fixed radar will control its function depending on results of detection and in a case where interference occurs, the fixed radar may default to an inactive mode. Table 1 below compares typical vehicle-mounted radars and fixed speed-monitoring radars.

Table 1.	Vehicle-mounted radar	Vehicle speed monitoring radar
Detection target	Vehicles, pedestrians, obstacles on the road-side	Vehicles
Detection parameter	Distance, speed, direction	Speed
Detection distance	- 200m	- 100m
Detection area	+/- 15 degrees	+/- 1 degrees
Radar method	FM – CW, pulsed-doppler, etc	CW radar
Installation height	< 2m	> 5m
Installation condition	Installed inside a vehicle	Installed without any covering
Controls	Yes	No
Transmission	Intermittent	Continuous

(2) Fixed Radar for Monitoring Pedestrians

One of the characteristics of this type of fixed radar is that it targets both pedestrians and vehicles. The area of the transmitted radar beam would be assumed to cover a traffic intersection. Therefore, the transmitted beam may cover a wider direction than vehicle-mounted radars and the detection distance may be less than that of a vehicular-mounted system. In addition, it is necessary to install these fixed radars high enough above the ground (hence typically be uncovered) to prevent the radar from being disabled by intervening objects such as a pedestrian standing in front of the beam.

Since these radars are designed to detect pedestrians and their movement through an intersection, they are somewhat similar to vehicular radars, and they are assumed to be able to detect speed, distance and direction. It is unlikely that the fixed radar will control its function depending on results of detection and in a case where interference occurs, the fixed radar may default to an inactive mode. Table 2 below shows a comparison between this type of fixed radar and vehicular-mounted radar systems.

Table 2.	Vehicle-mounted radar	Pedestrian monitoring radar
Detection target	Vehicles, pedestrians, obstacles on the road-side	Vehicles, pedestrians
Detection parameter	Distance, speed, direction	Distance, speed, direction
Detection distance	- 200m	- 40m
Detection area	+/- 15 degrees	+/- 45 degrees
Radar method	FM – CW, pulsed-doppler, etc	FM – CW, pulsed-doppler, etc
Installation height	< 2m	> 3m
Installation condition	Installed inside a vehicle	Installed without any covering
Controls	Yes	No
Transmission	Intermittent	Intermittent

(3) Fixed Radar for Monitoring Traffic Volume

A primary characteristic that can be assumed for this type of fixed radar is that it only targets vehicles. The radar beam is typically transmitted over an area that covers all lanes of traffic at a given location. A typical installation would be inside a pylon on the side of a road. These radar systems cannot use CW radar since they need to monitor traffic volume even if there is a traffic jam. As with the fixed radar systems discussed above, it is unlikely that the fixed radar will control its function depending on results of detection and in a case where interference occurs, the fixed radar may default to an inactive. As with the other systems, if interference occurs, disabling the detection function, the radar may become inactive. Table 3 below compares characteristics of this type of radar with vehicle-mounted radar systems.

Table 3.	Vehicle-mounted radar	Traffic volume monitoring radar
Detection target	Vehicles, pedestrians, obstacles on the road-side	Vehicle
Detection parameter	Distance, speed, direction	Distance, speed, direction
Detection distance	- 200m	- 100m
Detection area	+/- 15 degrees	+/- 15 degrees
Radar method	FM – CW, pulsed-doppler, etc	FM – CW, pulsed-doppler, etc
Installation height	< 2m	< 2m
Installation condition	Installed inside a vehicle	Installed inside a pylon
Controls	Yes	No
Transmission	Intermittent	Intermittent

(4) Fixed Radar for Airport Control

This type of fixed radar targets vehicles, aircraft, and falling objects in the vicinity of an airport. Its transmission area would typically be wide, the detection distance would be long, and the detection direction would covers 360 degrees. It would likely function by mechanical steering of a narrow beam. These radars would need to be installed at a location high above the ground with good visibility. As with the other systems discussed, this radar is used for surveillance only, and there are no control functions. Interference with these systems may result in the failure of objects in the beam to be properly displayed on radar monitor screens, or, possibly the display of non-existent objects. The characteristics of these systems are compared with vehicle-mounted radar in Table 4 below.

Table 4.	Vehicle-mounted radar	Airport Control
Detection target	Vehicles, pedestrians, obstacles on the road-side	Vehicles, aircraft, falling objects
Detection parameter	Distance, speed, direction	Distance, direction
Detection distance	- 200m	- 800m (Navtech radars)
Detection area	+/- 15 degrees	360 degrees (Navtech radars)
Radar method	FM – CW, pulsed-doppler, etc	FM – CW
Installation height	< 2m	> 3m
Installation condition	Installed inside a vehicle	Installed without any covering
Controls	Yes	No
Transmission	Intermittent	Intermittent

Effects of Fixed Radar on Vehicle-Mounted Radars

As described above, there are significant differences between vehicle-mounted radars and fixed radars in their usage and configurations. The following discussion is an analysis of the potential for interference between vehicle-mounted radars and one of the types of fixed radar systems mentioned above: radar systems used to monitor vehicle speed. Calculations were made to illustrate the potential for interference between such a fixed system and a vehicle-mounted radar.

For purposes of simplifying these calculations, the analysis assumes that antenna gain and transmitted power are the same between a vehicle-mounted radar system and a fixed radar installation. For purposes of this analysis the following assumptions were made: (1) the distance between the fixed radar and the vehicle-mounted radar is 40m; (2) the distance between the vehicle-mounted radar and the vehicle it is detecting (the "lead" vehicle) is 150m; (3) the RCS (radar cross-section) of the lead vehicle is 10 dBsm[1];

[1] **dBsm** (dB relative to square meter): decibel measure of the radar cross section (RCS) of a target relative one square meter. The power reflected by the target is proportional to its RCS. "Stealth" aircraft and insects have negative RCS measured in dBsm, large flat plates or non-stealthy aircraft have positive values.

(4) the vehicle-mounted radar uses a FM-CW system; (5) the fixed radar uses a CW (not modulated) system; and (5) the fixed radar continuously transmits radio waves at one specific frequency at the 76-77 GHz band.

For the vehicle-mounted radar system, the modulation frequency of the FM-CW radar is assumed to be 100 Hz, the sampling frequency is 1 MHz, and the frequency band range is 900 MHz. Assuming these parameters, we calculated a S/J (Signal-to-Jamming) ratio of -5.94 dB. [2] This means that the desired signal of the vehicle-mounted radar (*i.e.*, the reflected waves from the lead vehicle) would be masked by the interfering waves emitted from the CW radar. This would cause the vehicle-mounted system to lose the signal from the lead vehicle. Furthermore, this calculation assumes that the detected target is another vehicle. In the case where targets might be motorcycles or pedestrians, the reflected waves would be weaker, thus leading to a potentially greater undesirable masking of the signal.

The above calculation is one example of the potential for interference from fixed radar systems to vehicle-mounted radar. *If the use of fixed radars is allowed on an unlicensed basis, radars with various systems may appear in many locations, resulting in an increased risk of dangerous interference to vehicle mounted radars that may affect their performance.*

Conclusion

For vehicle-mounted radar systems the integrity of the detected signals is used for vehicular control. Therefore, the reliability of the detection is critical to system performance and for the safety and convenience of users. This discussion and the calculations discussed above are theoretical, as there is no sufficient data available currently. However, research has begun into the "real world" possibilities for serious interference between fixed radar and vehicle-mounted radar. Toyota urges the Commission to await the results of this research before proceeding to allow the co-existence of vehicle-mounted radars and unlicensed fixed radar installations.

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[2] Signal-to-Jamming (S/J) is the ratio of the desired signal level to the jamming signal level in the signal's bandwidth.

References

1. http://www.nmsu.edu/~traffic/Publications/Trafficmonitor/vdst.pdf
2. http://www.fhwa.dot.gov/publications/research/safety/00097/00097.pdf
3. http://ntl.bts.gov/lib/36000/36000/36061/ptmd_nc.pdf
4. http://www.nav-tech.com/

EXHIBIT 2

NRAO's Claim :

"More than 100km may be needed to attenuate a signal."

Radio wave attenuation in dry air is calculated as follows:

$$\Gamma = \underbrace{20\log\left(\frac{4\pi d}{\lambda}\right)}_{\text{Basic transmission loss in free space}} + \underbrace{0.000093d}_{\text{Atmospheric attenuation}}$$

Γ : Power loss [dB]
d : Distance to radio astronomy [m]
λ : wavelength [m]

Calculation parameters

Power radiated to a radio telescope: -20dBm/MHz
System sensitivity : -198dBm/MHz

Precondition

Radar output: 10dBm
Bandwidth: 1GHz
Interference threshold includes 10% margin
See ITU-R RA.769-2 for interference threshold

According to the simple calculation,

Separation distance: **Approximately 93 km**.
Therefore, 100 km distance seems reasonable.

However, this calculation does not consider several important factors.

TOYOTA

Reason (1): NRAO's claim is not realistic

Sensitivity equation

$$\frac{\Delta P}{P} = \frac{1}{\sqrt{\Delta f_0 t}}$$

Data from ITU-R RA.769-2

The condition for radio astronomy defined in Rec. ITU-R RA.769-2:

Δf_0 = 8GHz, t = 2,000 [sec.]

According to the above condition, the noise reduction effect is:

1/sqrt(16,000,000,000,000)

= -66 dB

Radar waves are scattered by the ground, trees, buildings etc, and seen as noises detected as by radio telescopes.

NRAO's calculation overestimates the radar interference by approximately 66 dB (about 4M times) in terms of power

Therefore,

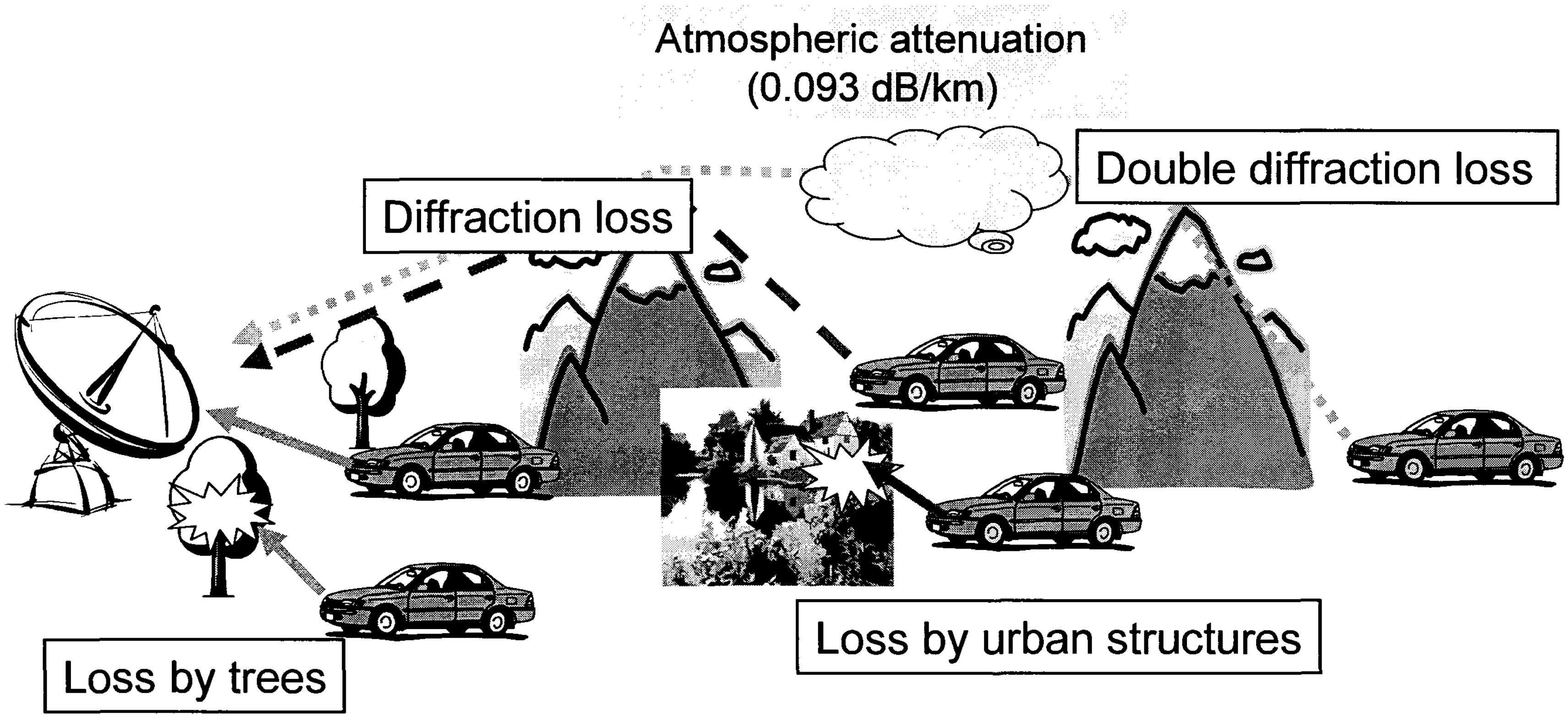
a more **realistic separation distance is about 0.12 km**

rather than 100 km.

TOYOTA

Reason (2): NRAO's claim is not realistic

The loss by trees, and loss by urban structures etc are also not considered.
In addition, data loss caused by radio wave interference is allowed up to 2 percent in ITU-R RA. 1513-1.



TOYOTA

Reason (3): NRAO's claim is not realistic

➢ About the calculation in NRAO comment #9:

The average power increase amount due to this amendment to the Radio Law is estimated as follows. However…

$$2.35/\left[(1-f)+f/187.5\right]$$

Traffic percentage of periods when a vehicle is not in motion

- ☐The f value is smaller in provincial cities, therefore the value used in the calculation is larger than the actual value.
- ☐The f value is larger in urban areas, but there should be a great power loss by buildings etc. This loss is not considered in the calculation.

TOYOTA

We believe the above discussion supports the fact that…

Toyota has 300,000 vehicles using radar systems worldwide for about 10 years, but no information they caused interference to radio astronomy.

If the separation distance proposed by NRAO is necessary, there should have been cases of radio wave interference.

Also, the FCC proposal is to amend the power limit when the vehicle is not in motion, but NRAO fails to comment concerning this significant change.

We believe 76-77GHz radars will be compatible with radio astronomy if FCC adopts the proposed limits.

TOYOTA